

Fermilab

TM-1197
6023.000

B VS. H CURVES FOR 1008 AND 1020 STEELS

A. Ito, W. Bosworth, A. T. Visser, J. Grimson, and W. Yang

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For the purpose of investigating the saturation regions, we have measured the B vs. H curves for the purchased 1008 and 1020 steels. In order to make a fair representation, the sample was chosen under the following conditions.

- 1) It was taken far away from the flame cutting region.
- 2) A hand saw was used to cut off the sample.
- 3) Finally the sample was machined into a toroidal shape of about 2" OD, 1.75" ID and 1/2" height.

We fabricated two samples of each type of steel in order to check the consistency of the measurements. The results are shown in Figs. 1 to 8.

For comparison, we plotted the curves on USS steel 1010 and 1020 respectively. As shown in Figs. 9 and 10, the measured curves are similar to that of hot rolled types of steel.

For convenience of the interested readers who want to run LINDA, TRIM or POISSON programs, we listed the values of B and H then computed values of B^2 and Gamma as shown in Tables 1 and 2. The samples were measured by Arnold Engineering, Marengo, IL.

We appreciate the technical assistance by J. Robb and L. Tung.



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Table 1
1008 Steel
7/1/83

B (Kg)	H	$B^2 (x 10^8)$	$H \left(\frac{\text{Amp-Turn}}{\text{meter}}, x 10^2 \right)$	$\gamma = \frac{1}{\mu} = \frac{H}{B} (x 10^{-4})$
0	-0.1	0	-.08	-
1.0	0.0	.01	0.00	-
1.5	0.1	.02	.08	.67
2	0.3	.04	.24	1.5
3	0.5	.09	.400	1.67
4	0.8	.16	.64	2.
5	1.0	.25	.80	2.
6	1.4	.36	1.11	2.333
7	1.9	.49	1.51	2.714
8	2.4	.64	1.91	3.00
9	3.4	.81	2.71	3.778
10	4.2	1.00	3.34	4.200
11	5.5	1.21	4.38	5.000
12	7.3	1.44	5.81	6.083
13	9.5	1.69	7.56	7.308
14	13.5	1.96	10.74	9.643
15	24.3	2.25	19.34	16.2
16	45.0	2.56	35.81	28.125
17	74.0	2.89	58.89	49.412
18	127.0	3.24	101.06	70.56
19	205.0	3.61	163.13	107.895



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Table 2

1020 Steel

7/1/83

B (Kg)	H (oersted)	B^2 ($\times 10^8$)	$H \left(\frac{\text{Amp-Turn}}{\text{meter}}, \times 10^2 \right)$	$\gamma = \frac{1}{\mu} = \frac{H}{B} (\times 10^{-})$
0	0	0	0.00	-
0.5	0.1	.0025	.08	2.
1	0.2	.01	.16	2.
2	0.4	.04	.32	2.
3	0.6	.09	.48	2.
4	0.8	.16	.64	2.
5	1.1	.25	.88	2.2
6	1.5	.36	1.19	2.5
7	2.0	.49	1.59	2.857
8	2.6	.64	2.07	3.25
9	3.6	.81	2.86	4.00
10	4.6	1.00	3.66	4.6
11	6.2	1.21	4.93	5.636
12	8.2	1.44	6.53	6.833
13	11.5	1.69	9.15	8.846
14	17.0	1.96	13.53	12.143
15	28.8	2.25	22.92	19.2
16	47.0	2.56	37.40	29.375
17	86.0	2.89	68.44	50.588
18	138.0	3.24	109.82	76.667
19	215.0	3.61	171.09	113.158

CURVE 6.8134

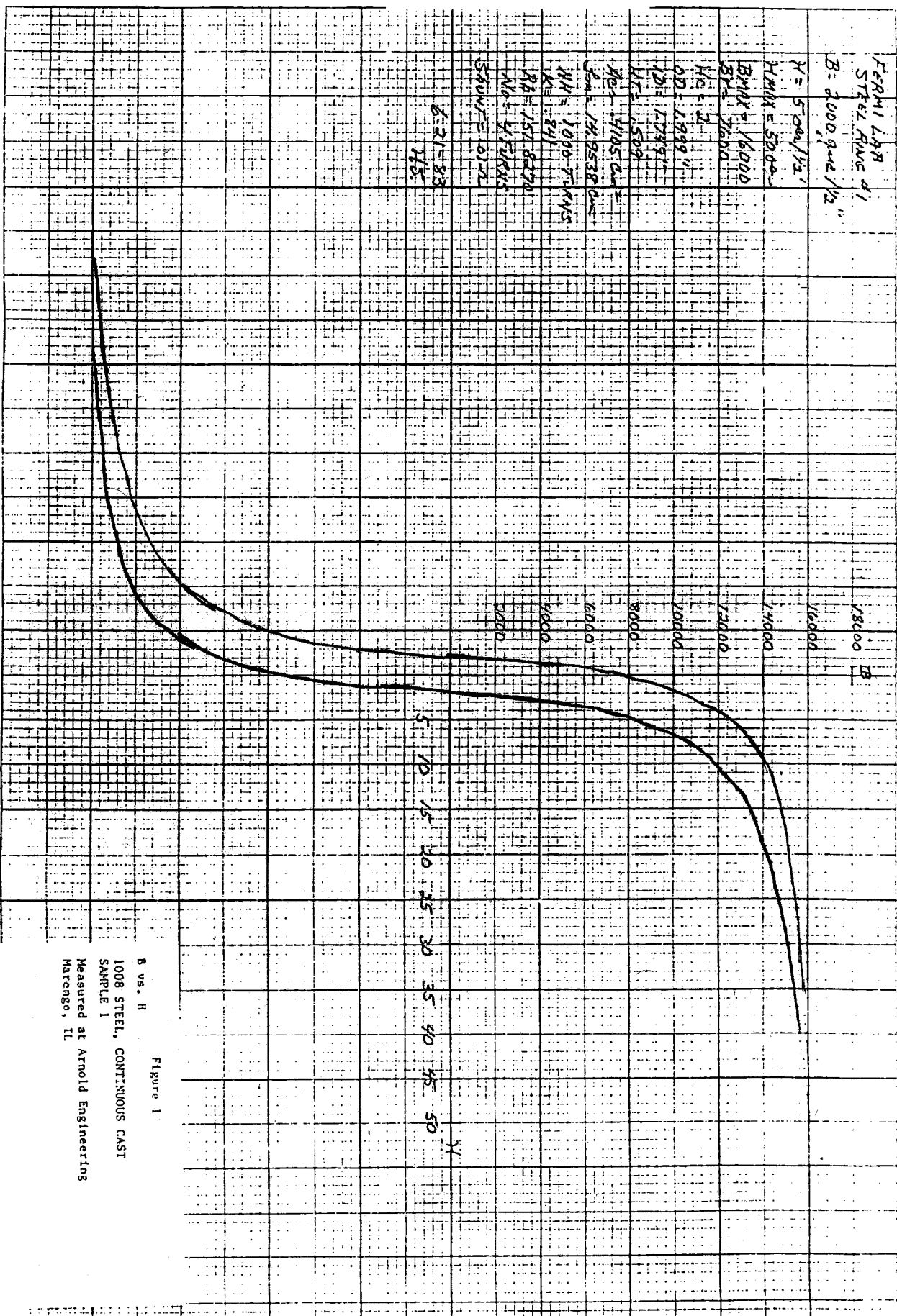


Figure 1
 B vs. H
 1008 STEEL, CONTINUOUS CAST
 SAMPLE 1
 Measured at Arnold Engineering
 Maricopa, IL

CURVE 68135

FERNI, L. AB
STEEL RHC #1

B = 3000 gms / 1/2"

X = 30.08 x 1/2"

Y MAX = 300.80

B MAX = 19.800

B1 = 19.00

H1 = 1.5

OD = 1.998"

ID = 1.949"

WT = 509"

H1 = 4105 cm

W1 = 14.9536 cm

H1 = 10.00 10.015

W1 = 6.140

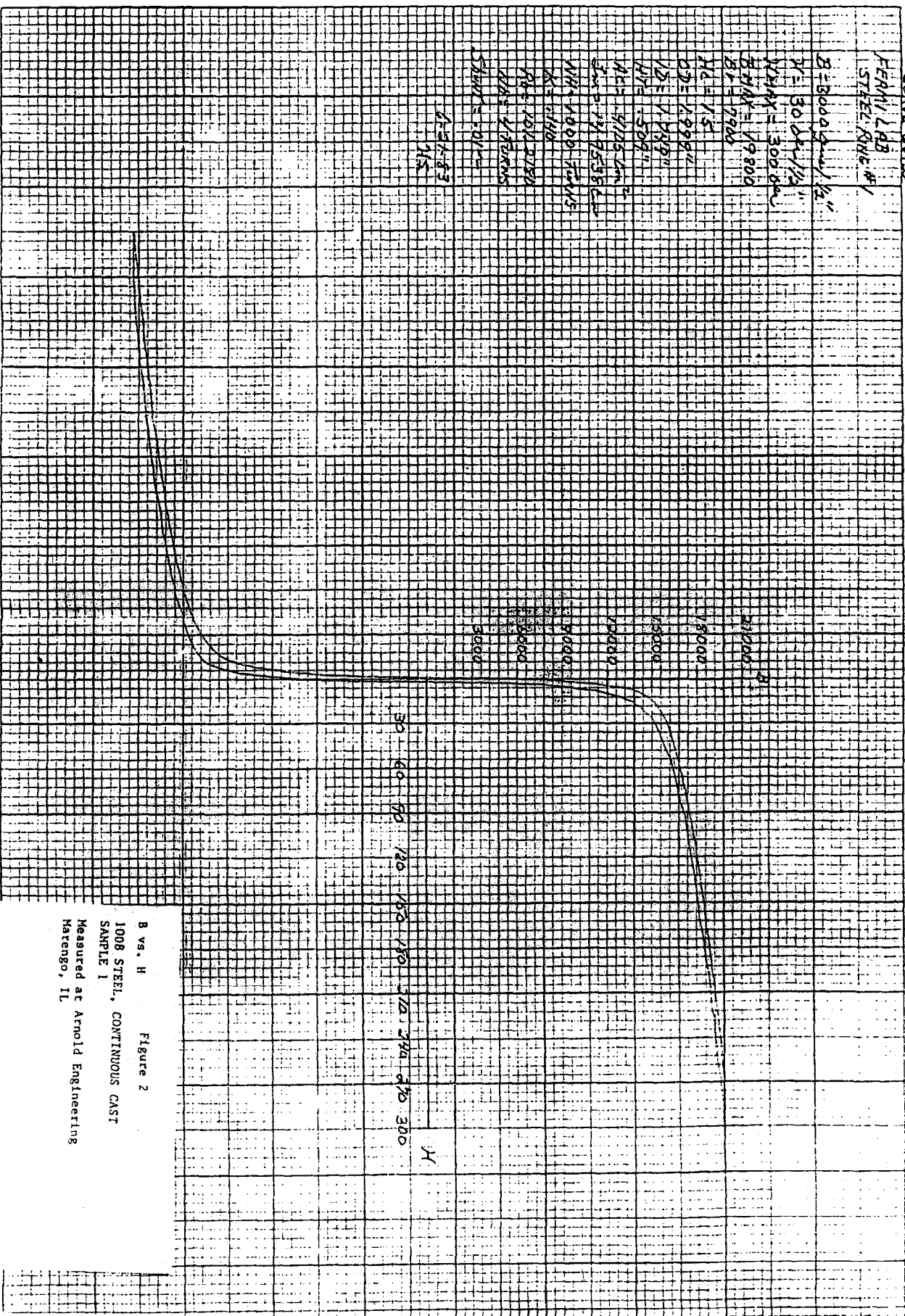
H1 = 10.0 0.780

W1 = 4.18000

STAMP = 10111

1.54-83

115



B vs. H Figure 2
1008 STEEL, CONTINUOUS CAST
SAMPLE 1
Measured at Arnold Engineering
Marengo, IL

CURVE 68136

FERMILAB
STEEL RING #2

B = 3000 pins/1/2"

H = 5000/1/2"

X MAX = 50000

Y MAX = 16000

BF = 11900

AC = 2

OD = 11900

TD = 11900

WF = 5000

AC = 11905 CM

2nd VM 95.37 CM

VM = 12000 TURNS

K = 1841

BF = 11900

VM = 11900

VM = 11900

VM = 11900

VM = 11900

VM = 11900

VM = 11900

VM = 11900

VM = 11900

VM = 11900

VM = 11900

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B vs. H

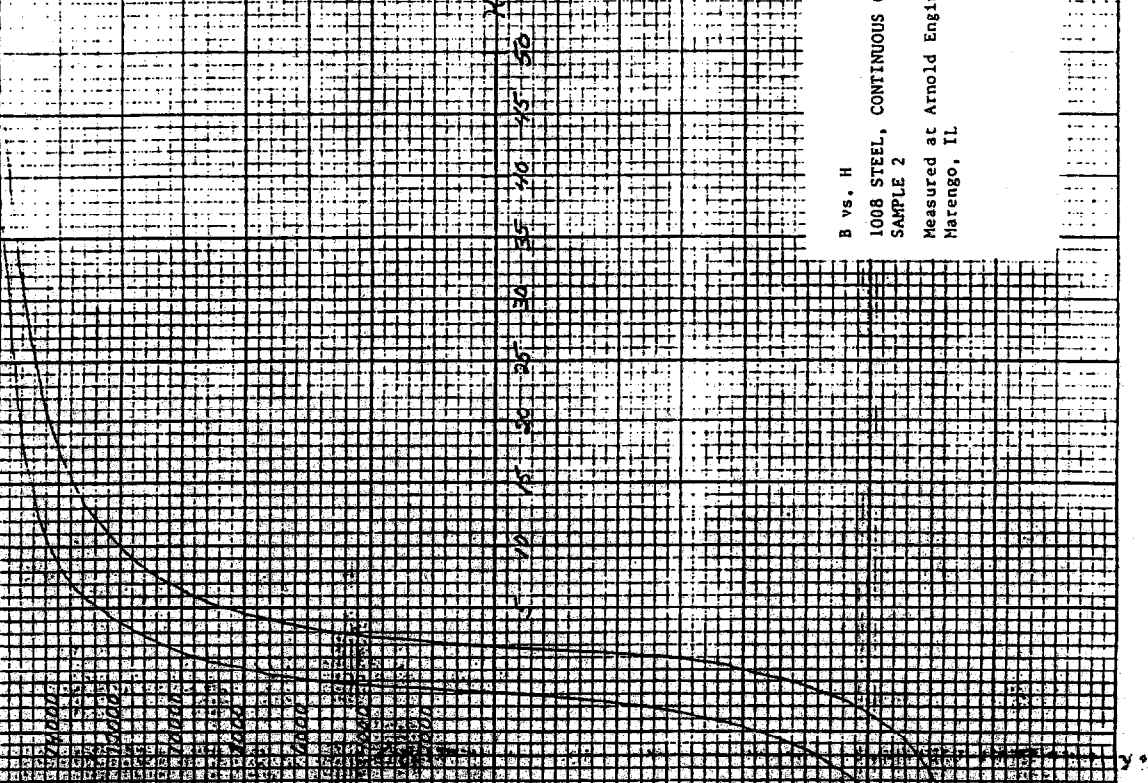
1008 STEEL, CONTINUOUS CAST

SAMPLE 2

Measured at Arnold Engineering

Marengo, IL

Figure 3



CURVE 68137

FERMI LAB
STEEL RING #2

YMM = 30000

BMH = 14600

BT = 8360

YC = 1.5

BD = 1.998"

UD = 1.249

WT = 5094

AC = 4105 G

SA = 14.93380

NA = 1000 F

BS = 30000.24 1/2"

Y = 30000.24 1/2"

X = 140

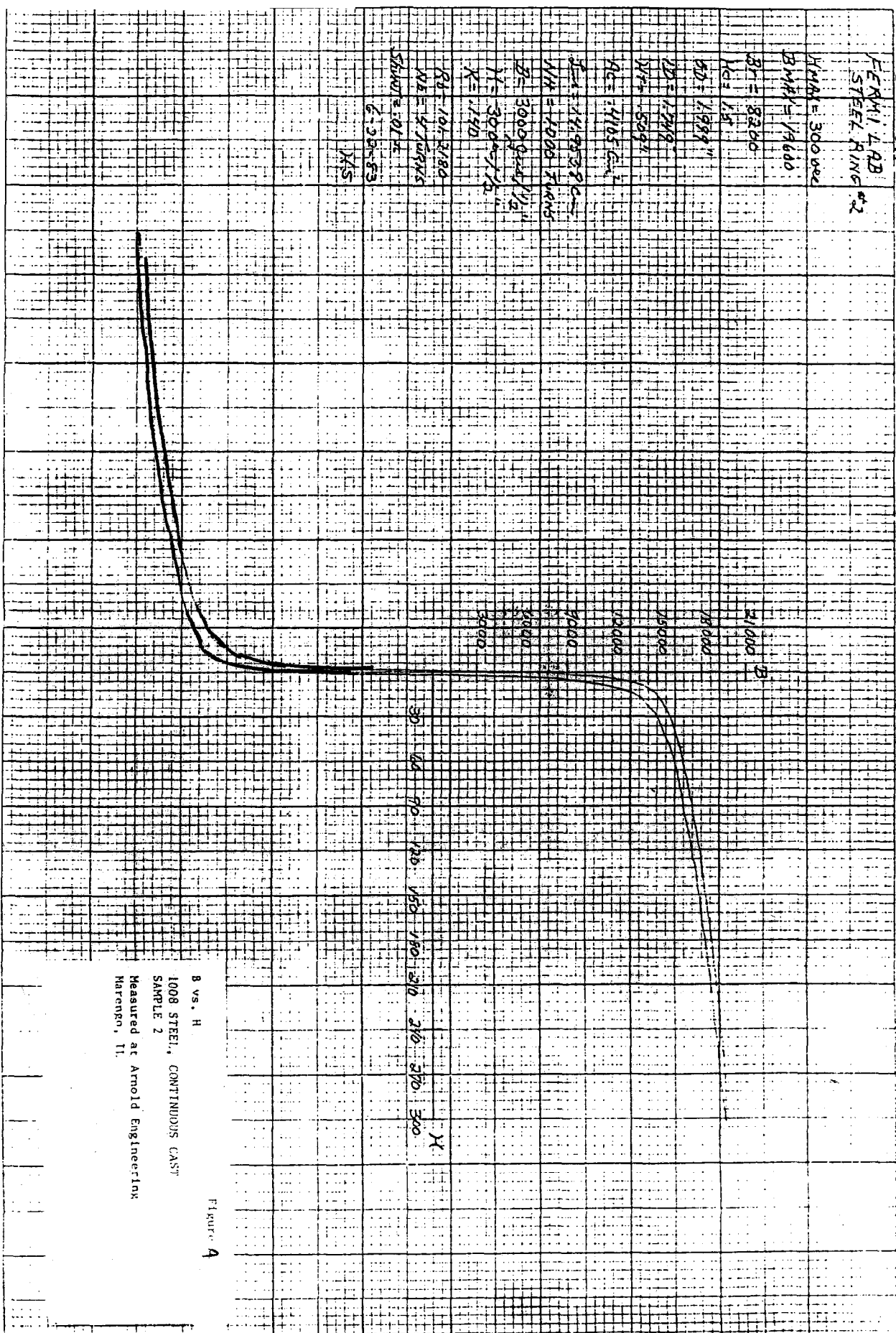
SB = 101.2180

NE = 4.10945

SHAD = 01.4

6.3853

AS



B vs. H
1008 STEEL, CONTINUOUS CAST
SAMPLE 2
Measured at Arnold Engineering
Narango, IL

Figure 4

CURVE 68158

FERRI LAB

STEEL RING #3

$B = 2000 \text{ g./in.}^2$

$H = 5.065 \text{ in.}$

$\Delta H = 5.00 \text{ in.}$

$B \Delta H = 10000$

$B \Delta = 3800$

$H_c = 5.3$

$B D = 1.999$

$V D = 1.750$

$H T = 1.490$

$A_c = 3.930 \text{ cm}^2$

$Z_c = 149.538 \text{ cm}^3$

$W H = 800 \text{ lb./in.}$

$K = 1.072$

$P_L = 158.3 \text{ K.G.}$

$N_b = 4.70 \text{ ANS}$

$S_{max} = 0.15$

6.03 G3

915

17000 B

16000

15000

14000

13000

12000

11000

10000

9000

8000

7000

6000

5000

4000

3000

2000

1000

0

10

20

30

40

50

60

70

80

90

100

110

120

130

140

150

160

170

180

190

200

210

220

230

240

250

260

270

17000 B

16000

15000

14000

13000

12000

11000

10000

9000

8000

7000

6000

5000

4000

3000

2000

1000

0

10

20

30

40

50

60

70

80

90

100

110

120

130

140

150

160

170

180

190

200

210

220

230

240

250

260

270

Figure 3

B vs. H
1020 STEEL, 2" PLATE
SAMPLE 3
Measured at Arnold Engineering
Marengo, IL

CURVE 68139

FERRY LAB

STEEL ANGLE #3

13 x 300 gms/1/2"

H = 30.44 1/2"

Hmax = 30.000

Bmax = 1.9800

B = 1.9150

Hc = 2.2

0.2 = 1.999

VD = 1.7500

W = 4.900

A = 3936.000

Em = 11.7580

W = 80.7000

K = 1/12

KA = 105.5230

W = 1.7000

SHAFT = 10.5

6.2383

255

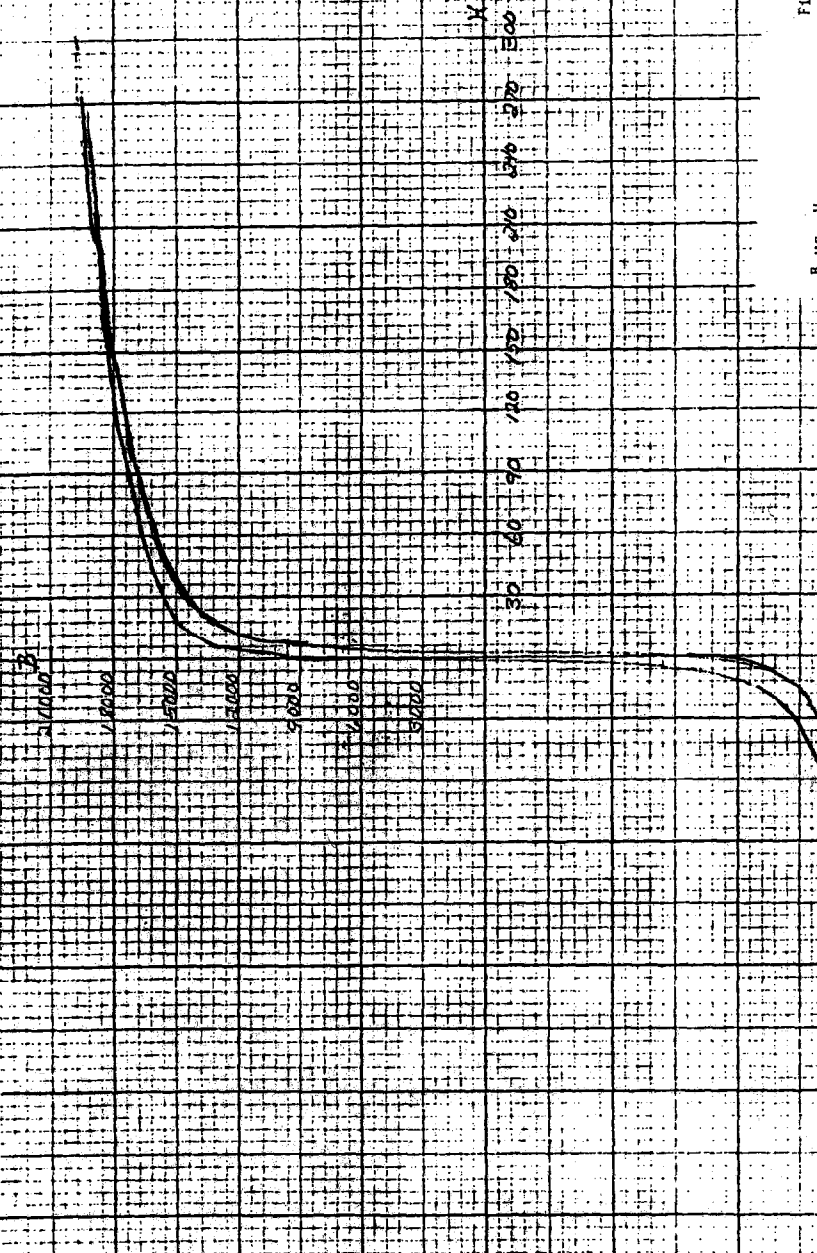


Figure 6

1020 STEEL, 2" PLATE
SAMPLE 3

Measured at Arnold Engineering
Marengo, IL

STEEL PING. WY
B: 7000 gms 1/2"

1644-5002

848 2300

027 1.939

At 40114

MA-800701

82-15519

$$54405 = 0.1n$$

6.858

Figure 1: A schematic diagram of a 1D lattice chain. It shows a horizontal line with several vertical segments representing lattice sites. The sites are labeled with 'a' and 'b' in a repeating pattern. A legend below the diagram indicates that 'a' represents a spin-1/2 particle and 'b' represents a spin-1/2 particle. The diagram is divided into two sections by a vertical line, with the left section labeled 'a' and the right section labeled 'b'.

100

Figure 1 consists of a 3x3 grid of small diagrams. Each diagram represents a quadrant of the eye (Superior, Inferior, Nasal, Temporal) and shows the spatial distribution of four types of cells (A, B, C, D). The diagrams are arranged in a 3x3 grid, with the top row showing the Superior quadrant, the middle row showing the Inferior quadrant, and the bottom row showing the Nasal and Temporal quadrants. The diagrams show the relative positions of the four cell types in each quadrant.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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100

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
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[illegible]

B vs. H
1020 STEEL, 2" PLATE
SAMPLE 4

Measured at Arnold Engineering
Marengo, IL.

CURVE 68141

FERRI LAB

STEEL ANGLE W4

B = 300.9 mm / 12"

H = 300.0 mm

Wt = 300.0 lb

B MAX = 17500

B MIN = 8600

Wt = 3.35

OD = 1.999

ID = 1.750

Wt = 500

AC = 1.4016

$I_x = 149578$

$I_y = 90000.8$

K = 112

PAF = 103.4611

NA = 470.0 ANS

SHAFT = 0.014

6.2383

MS

30000

18000

15000

12000

9000

6000

3000

0

-3000

-6000

-9000

-12000

-15000

-18000

-21000

-24000

-27000

-30000

X

300

240

180

120

60

0

-60

-120

-180

-240

-300

FIGURE 8

B vs. H

1020 STEEL, 2" PLATE

SAMPLE 4

Measured at Arnold Engineering
Marengo, IL



Hot Rolled Carbon Steel Plates

Grade 1010—Over .250 Inches
DC Magnetization

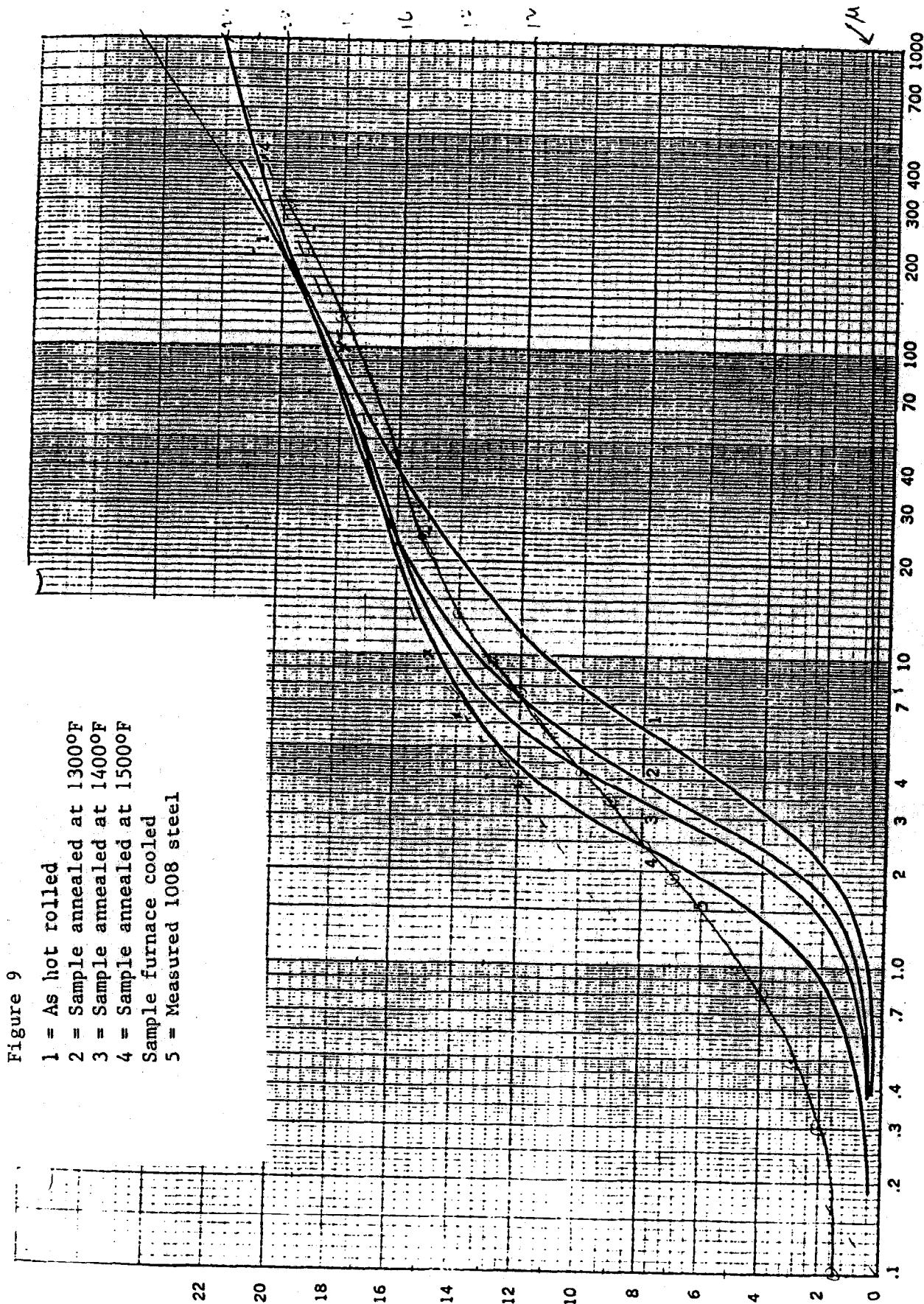


Figure 9

- 1 = As hot rolled
- 2 = Sample annealed at 1300°F
- 3 = Sample annealed at 1400°F
- 4 = Sample annealed at 1500°F
- 5 = Sample furnace cooled

μ for air

1008 measured



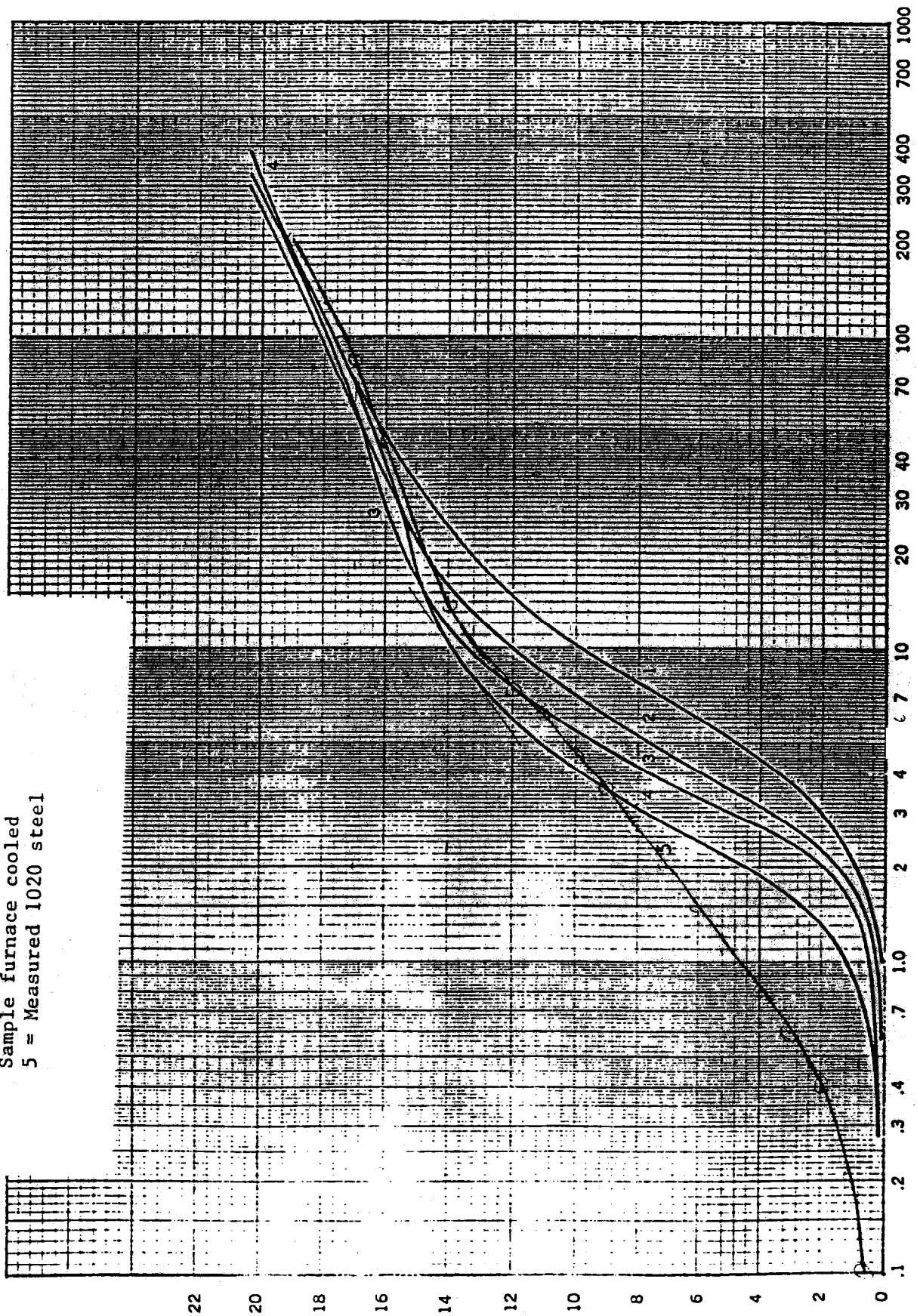
Hot Rolled Carbon Steel Plates

Grade 1020—Over .250 Inches

DC Magnetization

Figure 10

- 1 = As hot rolled
- 2 = Sample annealed at 1300°F
- 3 = Sample annealed at 1400°F
- 4 = Sample annealed at 1500°F
- Sample furnace cooled
- 5 = Measured 1020 steel



1020 measured